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SELECTION OF A SUITABLE ACCESS TECHNOLOGY TO COMMUNICATE WITH AN IOT DEVICE IN A COMBINED 5G AND 802.11AX/BE/BA NETWORK

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SELECTION OF A SUITABLE ACCESS TECHNOLOGY TO COMMUNICATE WITH AN IOT DEVICE IN A COMBINED 5G AND 802.11AX/BE/BA NETWORK

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ABSTRACT

This proposal provides efficient techniques to communicate with user equipment (UEs), such as Internet-of-Things (IoT) devices running critical applications in harsh environments, for combined 5G and Institute of Electrical and Electronics Engineers (IEEE) 802.11ax/be/ba networks, while also reducing power consumption and/or meeting other performance constraints for such devices.

DETAILED DESCRIPTION

The Non-roaming architecture for the Third Generation Partnership Project (3GPP) 5G core network with untrusted non-3GPP access and the Non-roaming architecture for the 3GPP 5G core network with trusted non-3GPP access are defined in 3GPP Technical Specification (TS) 23.501. The Target Wake Time (TWT) for IEEE 802.11ax is the time at which a user equipment (UE) participating in a TWT should wake up for the TWT session.

A TWT agreement allows a UE to participate in multiple periodic TWT session periods (SPs) in which it can wake up and communicate with an access point (AP), for example, via scheduled or contention based access for downlink (DL) and/or (UL) communications. A TWT wake interval is the time between successive TWT sessions for a given UE. Note, that a UE participating in a TWT session is allowed to wake up and access the medium using contention based access for UL transmission at any time instant.

Consider a scenario in which a UE (e.g., an IoT device running some critical applications, considering sensor as well as actuator functionality in that IoT device) is reading some parameters and communicating to an IoT application (app) running on an IoT server. The IoT app can analyze various parameters and send instructions to the device by sending commands to the actuator functionality on the IoT device. As noted, consider that the UE is running critical applications, is deployed in a harsh channel condition area (e.g., a factory floor), and is provided with 5G as well as IEEE 802.11ax/be radio interfaces for this deployment scenario. The UE may be able to reach the IoT server via one or both of the 5G and/or the IEEE 802.11ax/be access technologies at a given time. In some instances, the UE may also support 802.11ba (Wake-up-Radio (WuR)) functionality. Thus, for this scenario it may be desirable not only to use the best possible access technology available at a time but to reduce power consumption of the UE.

Consider that the UE will often enter into a sleep mode for one or both of these access networks. Thus, the network is to decide which access technology to utilize to communicate with the UE at a given time (and choose an option that should potentially result in lower power consumption for that UE as well as meet other performance constraints).

This proposal provides efficient techniques to communicate with user equipment UEs for 5G-IEEE 802.11ax/be/ba networks, while reducing power consumption for such devices and meeting various other performance constraints.

A first technique involves an enhanced method for decision making at an Access and Mobility Management Function (AMF) that can select a suitable access technology, while meeting other performance constraints (e.g., lower power consumption for the UE, delay in responding, reliability, etc.) in a 5G-802.11ax network.

Currently, an AMF can know the sleep schedule for the 5G access of a UE. However, the AMF doesn't know TWT-related information and/or other parameters for Wi-Fi accesses (e.g., IEEE 802.11ax/be accesses). Accordingly, the first technique provides for enabling a UE (for trusted as well as untrusted use cases over 802.11 accesses) or an AP/Wireless LAN Controller (WLC) to inform the AMF about a TWT session and/or other related parameters as follows. Figures 1 and 2 illustrate example details associated with various techniques described herein in which Figure 1 illustrates example details for a trusted wireless local area network (WLAN) integration with a 5G core via a Trusted Non-3GPP Gateway Function (TNGF) and Figure 2 illustrates example details for an untrusted WLAN integration with a 5G core via a Non-3GPP Interworking Function (N3IWF).

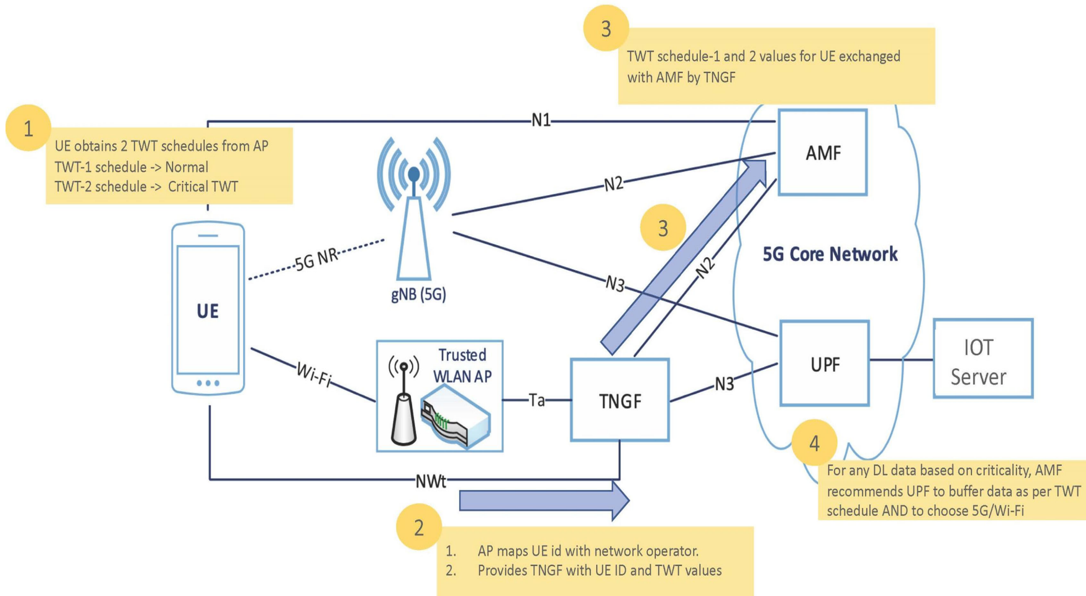

Figure 1: Trusted WLAN Integration with 5G Core via a TNGF

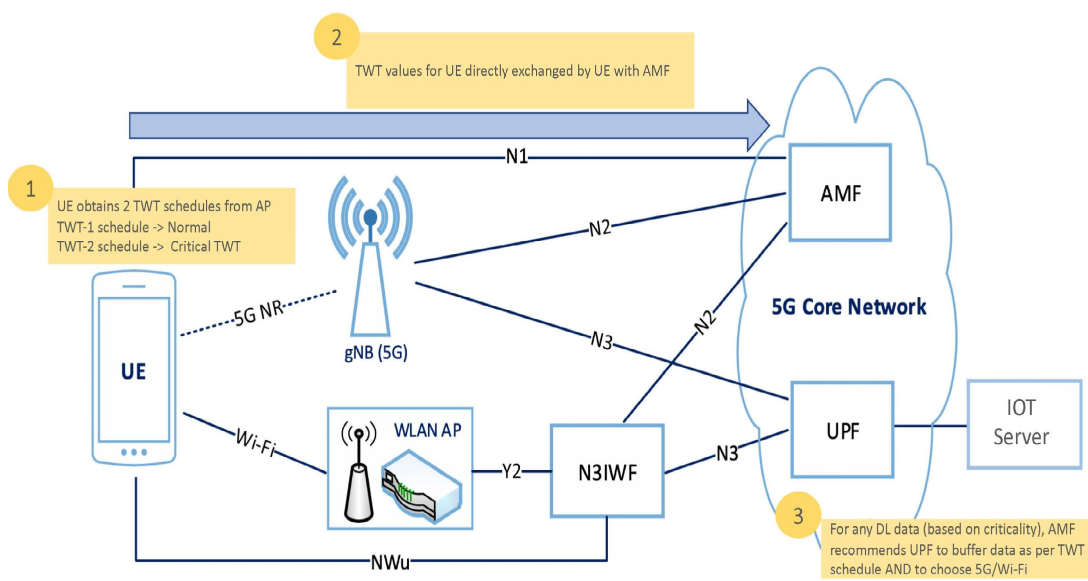

Figure 2: Untrusted WLAN Integration with 5G Core via a N3IWF

For the trusted use case involving the first technique, the AP/WLC can inform the TNGF regarding the 802.11 TWT values and the TNGF communicates the values to the

AMF (i.e., AP/WLC --> TNGF --> AMF) by adding suitable objects for the 802.11 TWT values. To provide such information, the 802.11ax AP/WLC needs to know the identity of the UE and the 3GPP core network provider with which it wants to communicate.

For 802.11ax APs that support Hotspot 2.0 / 802.11u, the UE can interact with the AP using Generic Advertisement Service (GAS) and/or Access Network Query Protocol (ANQP) messages after the UE receives 802.11u beacons (or contacts the AP using a Probe Request with an interworking service element) and the AP can infer some information with this process. For example, if the AP uses certain Service Set Identifier (SSID) for operator X and UE associates with SSID X as part of this procedure, the AP can provide that information (for this UE) to the TNGF.

For obtaining a Subscriber Identification Module (SIM) identifier (such as an International Mobile Subscriber Identity (IMSI)) of the UE, it is assumed that the UE has already associated in Wi-Fi network and completed Wi-Fi specific security procedures. Thereafter, the AP can be allowed to ask the UE for its IMSI over this secure connection. Other methods can be envisioned for obtaining such identities from a UE and to allow the AP to communicate such identities to the TNGF and thereafter to the AMF.

For the untrusted case involving the first technique, the 802.11 UE can directly inform the AMF regarding the 802.11 TWT schedule that it is using. This can be done by adding suitable objects in a Non-Access Stratum (NAS) message. In some instances, such a UE initiated message (e.g., 802.11 UE --> AMF communication including suitable objects for 802.11 TWT) can be used for the trusted case as well.

In some instances, certain UEs can be provided a recommendation to use two TWT schedules over the 802.11 access for some critical situations (e.g., when they want to be in sleep mode to conserve power but also want to be ready to quickly wake up to receive DL commands from an IoT server and responding to such commands).

This recommendation can be provided to UE via an analytics module or logic that can be provided for a network management element and can be for some specific time intervals (e.g., for 60 min when there is high load on the 5G network). The 802.11ax UE (i.e., the 802.11ax UE part of an 802.11ax/5G UE) can negotiate two TWT schedules as follows. For TWT schedule I, the 802.11ax UE can negotiate a TWT schedule with an 11ax AP using usual procedures. The AMF can be made aware of this negotiated TWT schedule, especially for UEs with large TWT values (e.g., sleep interval associated with a TWT value above a threshold). In addition, the UE can negotiate a new TWT schedule, TWT Schedule II, between the 802.11ax UE and the AP specifically for the purpose of processing high priority messages via the 3GPP core network. A UE that is configured (or expecting) to receive a high priority DL message via the 3GPP core network and wants to be ready to process such a message can use the TWT schedule II. The AMF can also be made aware of the TWT schedule II using techniques as discussed above.

The AMF uses the various information (e.g., 5G as well as 802.11ax TWT / sleep schedules, along with other parameters and policies) to determine whether to wake up a 5G UE or 802.11ax UE if both are in the ECM-Idle state (while meeting various performance constraints in terms of power consumption for the UE as a result of one of these actions, latency, etc.). In some instances, this analysis can also be performed at a separate analytics server and recommendations can be provided to AMF for the action to be initiated.

For the untrusted non-3GPP (i.e., Wi-Fi) access, the AMF is also allowed to use these TWT values to indicate to the N3IWF using N2 signaling to use a large value for a keep alive timer for Internet Key Exchange (IKE) and/or Internet Protocol (IP) security (IPSec) to avoid tearing down of an IPsec tunnel (for control plane messages) between the UE and the N3IWF (e.g., when the 802.11ax UE is in sleep mode with a large value of TWT).

As a downlink packet arrives at UPF for this UE, the UPF contacts the AMF regarding the packet. As the UE is in the ECM-Idle state, the AMF can check to determine the TWT / sleep schedules and related parameters for 5G as well as 802.11 access for the UE. If the AMF determines that the UE may come out of the power save mode soon, the AMF communicates with the UPF to wait for that (short) period and gives additional routing / forwarding information after that short period. The 802.11 TWT Schedule I can be used along with the 5G sleep schedule and related parameters for decision making for the UE when a normal priority DL message is obtained for the. If an IoT server indicates that it is a high priority message for the UE, TWT Schedule II can be used for the decision making at the AMF (along with the 5G sleep schedule, 802.11 TWT schedule I, and related parameters).

For a second technique as an enhancement to the first technique for instances in which the UE also supports 802.11ba (WuR) functionality for reduced power operation, the UE is allowed to indicated whether or not it is ready to move out of the sleep mode using an 802.11ba wake up message (by the 802.11 AP sending that message to the 802.11ba radio of the UE) even if the time period associated with the TWT negotiated in 11ax (or 11be) mode has not expired.

For an 802.11ax UE that also supports 802.11ba (i.e., wake up radio operation) with 11ax / TWT, a DL message is provided from the TNGF or N3IWF via AP even if the TWT is not expired. If the UE has agreed that higher priority is be given to certain messages coming from 3GPP core network even if it is within a sleep time interval (i.e. the sleep time used for pure 802.11ax or 802.11be mode operation) that is not expired, the UE is woken up by using the 802.11ba (secondary radio) and the process discussed above continues for this enhanced use case.

A third technique is also provided as a further enhancement of the first and second techniques for IEEE 802.11be networks (involving 5G-802.11ax/be devices). IEEE 802.11be (Extremely High Throughput (EHT)) is being designed for 2.4 GHz, 5 GHz, and 6 GHz bands. It is expected that 802.11ax may also start using the 6 GHz band.

Many 802.11 APs offer concurrent functionality in the sense that they can communicate over 2.4 and 5 GHz bands simultaneously. However, most current 802.11 UEs are non-concurrent (i.e., they operate in either 2.4 Ghz or 5 GHz at a time even if they support both the radios). 802.11be is considering non-concurrent as well as concurrent option for 802.11be UEs. With such operation, it would become possible for a UE to use a different combination of bands simultaneously (such as 2.4 and 6 GHz, or 5 and 6 GHz, or 2.4, 5 and 6 GHz).

Generally, a non-concurrent 802.11ax UE can use one frequency band and negotiate TWT with an 802.11ax AP and the TWT can be processed at the AMF and the AP as discussed above. However, a concurrent 802.11 be / 11ax UE can be allowed to negotiate different TWT values for different frequency bands in accordance with the techniques of this proposal.

For example, a concurrent UE may want to switch off the 2.4 GHz band in a given time interval or switch off the 5 GHz band in some other time interval (e.g., for power saving purposes). In the methods discussed above, a TWT value is communicated (if larger than a given threshold) to the AMF via a UE for untrusted / trusted access (or via AP for trusted access). However, an 802.11be UE can have different TWT values for different frequency bands and these could be negotiated / activated at different points in time in accordance with techniques of this proposal. Thus, a TWT value communicated to the AMF may not be the best TWT value for concurrent 11be UEs.

Accordingly, for 5G/11be networks (novel) various operations can be performed. In one instance, the most relaxed (e.g., least constrained) value of TWT can be communicated from a concurrent UE to the AMF. For example, an 802.11be UE may negotiate TWT1 for the 2.4 GHz band and communicate the TWT1 value to the AMF. Thereafter, the UE may negotiate TWT2 for the 5 GHz band at a later point in time. If the UE determines that TWT2 (for the 5 GHz band) offers less constraints than TWT1 (for the 2.4 GHz band), the UE can communicate updated value of the TWT (e.g., TWT2) to the AMF.

In another instance, the UE can be allowed to communicate TWT values along with other parameters such as the type of UE (concurrent vs non-concurrent) and/or frequency band for which a given TWT applies (in the case of a concurrent UE) to the AMF. In this case, the AMF can use this information along with its configured policies to determine the TWT or band that it is to use to take make decisions as discussed above.

Finally, a fourth technique is provided as a cross-optimization of the sleep time and TWT schedules, as aided by a network management system or the like. In this technique, negotiation of TWT between an 802.11ac UE and an AP are allowed, which take into account the sleep time value that a given UE may have already negotiated on the 5G access and vice-versa.

To provide such operation, an 802.11ax AP and 5G gNodeB can communicate relevant parameters (for a given negotiation) to the network management system and TWT/sleep cycle values for each access are negotiated between the AP and the network management system and between the AP and the UE.

For example, consider a 5G-11ax UE that has already negotiated a periodic sleep interval using a 5G access for a 5G Radio Access Technology (RAT) type. As this 11ax

UE negotiates TWT (for 11ax access) with an 11ax AP, this AP communicates with the network management system and negotiates a set of suitable values of TWT schedules for that UE. The network management system can consider the 5G periodic sleeping schedule being used by the 5G-11ax UE, the TWT schedule requested by the UE, similar parameters from other UEs, Quality of Service (QoS) requirements in the network, and/or other relevant parameters to suggest to the 11ax AP a suitable set of values of 11ax TWT schedules for the UE. Next, the network management system can use that schedule to negotiate a suitable TWT schedule with UE.

Alternatively, such operations can be performed in distributed manner with the 11ax AP and 5G gNodeB communicating with each other for this purpose. Thus, this technique can provide higher flexibility in meeting conflicting power saving, QoS, fast response time, and/or other requirements of such concurrent devices.

In summary, this proposal provides efficient techniques to communicate with user equipment UEs for combined 5G-IEEE 802.11ax/be/ba networks, while also reducing power consumption and/or meeting various performance constraints for such devices.